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ABSTRACTS.

PAPERS READ AT THE WASHINGTON MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

Glacial Observations in the Umanak District, Greenland. By GEO. H. BARTON.

A party consisting of six persons under the direction of Professor Alfred E. Burton, of the Massachusetts Institute of Technology, was landed by the Sixth Peary Expedition at the village of Umanak, Lat. 70° 30′, on an island in Umanak fiord, August 5, 1896. On September 9 the party was again taken on board for the return home. Between these dates observations were carried on upon the marginal area of the continental ice-cap to a distance of fifteen miles inland, and upon the glacial tongues passing down from the ice-cap by the various valleys leading into the Karajak and Itivdliarsuk fiords.

The region of the Umanak District was selected for investigation because of the facilities offered for much to be seen in the short time at the disposal of the party. Easy access to the edge of the inland ice by means of the larger fiords, the many glaciers large and small descending near or into the waters of the fiords, the great number of icebergs constantly passing out into the open waters of Baffin's Bay, and finally the fact that this region had not been visited by Americans, caused the selection.

Access to the surface of the inland ice was obtained from the nunatak lying between the Greater and Smaller Karajak glaciers. Considerable difficulty was encountered in getting upon the surface owing to the precipitous, generally vertical, sometimes overhanging character of the edge, rising from ten to forty feet. In only three places for a distance of over twenty miles did the edge present an inclined surface sufficiently gentle in slope to allow of ascent or descent.

In attempting to pass inland upon the ice the crevassing of the Greater Karajak glacier was found to extend far backward so that our course had to be deflected for several miles and finally to pass along the neutral ground between the two Karajaks. The elevation of the ice surface where first reached was about 1500 feet above sea level, while our fartherest point inland was about 2950 feet in elevation.

For a distance of about two miles the surface of the ice is very rough, consisting of a series of billows, very much like a frozen short, choppy sea. Over this it was very difficult to drag the sledge which constantly upset. This area was also full of dust holes from the size of a pencil to three feet in diameter and an average depth of about two feet. These were filled nearly to the surface with water and had a layer of dust in the bottom, an inch or two in thickness.

Beyond this we passed through a crevassed area for two or three miles and then came to a broadly rolling, undulating area which stretched away as far as the eye could reach looking like the American prairies in winter. The surface here was hard and crisp so that walking was very easy.

One lake was seen with several small streams flowing into it and one large stream flowing from it toward the land. Small streams were constantly encountered except in the crevassed area all flowing toward the land or toward the lake. One large stream, twenty to thirty feet across, and twenty to twenty-five feet deep, including five feet of water, was found at the farthest point reached flowing directly away from the land toward the interior.

No detritus was found on the inland ice except the dust in the dust hole area. Outside of this area the water of the streams was clear and their channels showed only clear ice.

The two important glaciers studied were the Greater Karajak and the Itivdliarsuk glaciers. The first of these has a width of about five miles and a length of from ten to fifteen miles from the edge of the inland ice to the waters of the fiord at its frontal face, but the crevassing of its current passes backward several miles into the mass of the inland ice. The elevation of the surface of the glacier as it first leaves the margin of the inland ice is about 1500 feet above sea level while directly at its frontal face it is about 500 feet. This gives a gradient of about 1000 feet in a distance of about ten miles, or 100 feet to the mile.

The rate of motion was carefully studied by Professor Burton during a period of nearly thirteen days. The result showed that there was an eddy in the ice at the point where the observations were made, as the ice near shore was moving slightly upstream. At a distance of 1708 feet it was stationary, while at a distance of 3396 feet the motion amounted during this time to 30.20 feet or 2⅓ feet per day. Up to this distance stakes had been set in the ice. At a distance of 2.4 miles a peculiarly shaped pinnacle furnished a point of observation. This was found to move during the same time a distance of 236 feet or about 19 feet per day.

This was the only case in which the actual rate of motion was determined. The Itivdliarsuk, three miles in width, was crevassed completely to the shore margin so that it could not be traversed with any safety, and no attempt was made to determine the rate of the smaller ones. Neither of these large glaciers carry any detritus either superglacial or englacial, except in the case of the Itivdliarsuk. Small nunataks near its source furnish two medial moraines which can be traced nearly throughout its length on the surface but are largely incorporated as englacial material before reaching the terminus. The edge of the larger glaciers like that of the inland ice is almost always nearly vertical with a height of from ten to forty. The structure is distinctly banded usually, apparently due to a shearing of the upper portions over the under from the central portions of the stream shoreward, the layers being inclined away from the shore.

Lateral streams flowing along the margin often cut caverns into the ice by means of which opportunity is furnished to study subglacial action. Small bowlders caught between larger ones or between a larger one and a projecting ledge are often broken into small fragments or ground to powder. In the case of rapid motion of the ice, distinct vacant spaces are left between the lee of a boss of rock and the ice, but where the motion is slow the ice is kept pressed against the lee side of the boss taking on a fanlike structure as it is pressed downward.

Lateral moraines along the sides of the glaciers are always present. They consist of a mixture of angular, subangular and rounded fragments, usually with considerable sand and a little clay, and occasionally largely made up almost entirely of till-like material.

From the edge of the inland ice and also from the detached ice-caps of the Nugsuak peninsula a large number of smaller glaciers descend the more or less narrow gorges, some reaching sea level and discharging icebergs, but the majority terminating from 100 to 1000 feet above the sea. The gradient of descent varies strongly in the various ones. In some it is very steep, in some very gentle, while many have a great change in various portions of their own length.

With two exceptions all the glaciers show evidence of diminution in length and depth, in older terminal moraines and glaciated surfaces farther down the valleys and older lateral moraines higher up the sides.

The two exceptions, near Sermiarsut on the Nugsuak peninsula seem to be overriding terminal moraines of not great age but these were seen toward the last of my work and were not carefully studied.

Everywhere throughout the regions visited there is evidence of the former greater extension of the inland ice, it having covered all the highest peaks, passed out over the ends of the promontories, filling the fiords and passing into the waters of Baffin's Bay.[1]

The peaks which present sharp serrated edges toward Baffin's Bay are distinctly rounded on the sides toward the inland ice; the highest points visited show abundant roche moutonnée forms, and everywhere erratics are freely scattered.

The Origin and Relations of the Grenville and Hastings Series in the Canadian Laurentian. By FRANK D. ADAMS and ALFRED E. BARLOW, with observations by R. W. Ells.[2]

This paper may be regarded as a continuation of two former papers[3] by Adams, treating of the Laurentian of Canada and presenting the results of further work. It deals more especially with the probable origin of the Grenville series in the light of recent studies by the authors of a very large Laurentian area in central Ontario, along the margin of the protaxis and north of Lake Ontario.

The northwestern portion of the district in question is underlain by the Fundamental Gneiss, which is believed to form part of the original crust of the earth and to be of igneous origin. The southeastern portion is occupied chiefly by the thinly bedded calcareous rock of the Hastings series, a series of undoubtedly sedimentary origin, but of unknown age, separated, however by a long erosion interval from the overlying Cambro-Silurian, and having certain petrographical resemblances to the Huronian of the typical area north of Lake Huron. Between these two series of rocks is an irregular belt of the Grenville series, identical in all respects with that of the original Grenville area in the province of Quebec. The character of these several series is described and their resemblances and points of difference indicated.

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[1] See paper by writer in American Geologist, Vol. XVIII, pp. 379–384, 1896.

[2] The paper appears in the American Journal of Science for March 1897.

[3] Ueber das oder Ober Laurentian in Canada. Neues Jahrbuch für Mineralogie. Beil. Bd. VIII, 1893.

A Further Contribution to our Knowledge of the Laurentian.—Am. Jour. Sci., July 1895.

The Grenville series differs from the Fundamental Gneiss in that it contains certain rocks whose composition marks them as highly altered sediments. These rocks are in part limestones and in part certain peculiar gneisses, rich in sillimanite and garnet, having the composition of shales, or very rich in quartz and passing into quartzite, having thus the composition of sandstones. These rocks, as has been shown in one of the papers above referred to, usually occur in close association with one another, and are quite different in composition from any igneous rocks hitherto described. These rocks it is which are considered as characterizing the Grenville series. They usually, however, form but a very small proportion of the rocky complex of the areas in which they occur, and which, owing to their presence, are referred to the Grenville series. They are associated with, and often enclosed by, much greater volumes of gneisses and amphibolitic rocks, identical in character with those of the Fundamental Gneiss. The limestones are also almost invariably penetrated by great masses of coarse pegmatite, and in some cases large bodies of the limestone are found imbedded in what would otherwise be supposed to be the Fundamental Gneiss. The whole thus presents the character of a series of sedimentary rocks, chiefly limestones invaded by great masses of the Fundamental Gneiss, and in which possibly some varieties of the gneisses present may owe their origin to a partial admixture of sedimentary material with the igneous rocks by actual fusion. There is, however, no reason to believe, from the evidence at present available, that any considerable proportion of the series has originated in the last mentioned manner.

From the relations of the several series, as displayed in central Ontario, it is believed that the sedimentary portion of the Grenville series is but a modified part of the Hastings series, that in fact the present relations of the Grenville series are due to a commingling of portions of the Hastings series with the Fundamental Gneiss along their line or zone of contact. The Fundamental Gneiss upon which the Hastings series was originally laid down having at a subsequent time been softened by the influence of heat, and having under the influence of dynamic action eaten into and fretted away the overlying Hastings series, giving rise to an intermediate zone of mixed rocks which constitutes the Grenville series. The relations of the two series being thus very similar to that shown by Lawson and Barlow to exist between the Huronian and the Fundamental Gneiss in the districts about Lake Superior and Lake Huron.

The appended remarks by Dr. Ells deal with the district to the east and northeast of that studied by Adams and Barlow, and show that here also the same series can be recognized and that the same relations between them obtain.

The Origin and Age of the Gypsum Deposits of Kansas. By G. P. GRIMSLEY.

Among the minerals of economic importance in the state of Kansas, gypsum occupies a prominent place, and it has attracted the attention of geologists for many years. At the present time the state stands first in the Union in value of its gypsum product. The deposits of ecomic value occur in a belt trending northeast-southwest across the state with a length of 230 miles and in width varying from five miles at the north to thirty-six miles near the southern line. There are three important areas: northern, central, and southern. Intermediate deposits connect the northern and central areas, while the interval between the central and southern is occupied by salt beds. The topography increases in ruggedness southward. In the northern area three companies are engaged in plaster manufacture. There are six mills in the central area, and two in the southern. The rock is white or a gray mottled, with a saccharoidal texture in the upper portion, but becomes more compact below. The dip is toward the west. In the central area occur a number of secondary gypsum dirt deposits, which form the basis of the greater portion of the plaster manufacture. This material is a granular dirt of an ash-gray color. It is soft, and readily shoveled into cars, so that it is ready for calcining with less labor and expense than in the case of the solid gypsum. At the present time four of these deposits are worked. Under the microscope the dirt is seen to consist of a mass of small angular gypsum crystals of varying size. Mingled with the gypsum crystals are small quartz crystals, some calcite poorly crystallized, and traces of organic material. The deposits are found in low, swampy ground near small creeks, and strong springs occur in most of them. Usually there is a ledge of rock gypsum at the same level, or ten to twenty feet below. The gypsum beds are all Permian, ranging from the Neosho epoch to the close, and they rise geologically to the south. The northern and central rock gypsum deposits appear to have been formed in the same gulf cut off from the western Permian sea; while the gypsum dirt deposits are secondary and of recent age. The southern deposit was formed in a shallow gulf cut off from the Permian sea at a later period not far from the close. Salt appears to have been deposited with the gypsum, but now it is only found farther out in the old gulf where it was thicker.

The Cornell Glacier, Greenland. By RALPH S. TARR.

In this paper attention is called to the recently published conclusions of Professors Salisbury and Chamberlin that glaciation on the Greenland coast has not in recent times extended much further than the present ice margin. The evidence upon which this is based is stated, and it is pointed out that another interpretation of the rugged topography of the high parts of the Greenland coast is possible. This is, briefly, that the peaks seen from a passing vessel present the face which is least likely to be glaciated; also that they have been longer exposed to denudation, both preglacial and postglacial, and that, being higher than the surrounding land, they were more rugged before the ice came, and reaching up into the glacier they were less scoured by the ice than is the case with the lower lands.

The description of the geological conditions and evidence of glaciation upon the Upper Nugsuak peninsula (latitude 74° 10′–15′) follows, and it is pointed out that the higher points in this region have all been covered by ice notwithstanding the fact that, as seen from the sea, the topography of the peaks is as rugged as that of other parts of the Greenland coast. Small beds of till and numerous transported pebbles, whose origin is somewhere within the ice-sheet, are found on the highest points. The Devil's Thumb, rising 2650 feet above the sea, has been glaciated; Wilcox, 1400 feet high, and twenty-five miles from the margin of the ice, has also been ice covered, and the glacier has extended over the Duck Islands, which are eight or ten miles further to sea than this. Adding to the land height the depth of the water in the neighboring bays, it is certain that at the Devil's Thumb the ice-sheet was not less than 3000 feet thick; that at Wilcox Head, twenty to twenty-five miles from the present ice margin, there was glaciation to a depth of certainly not less than 2000 feet, and that at the Duck Islands, thirty or thirty-five miles from the present glacier, the ice-sheet had a depth of not less than 600 feet. In other words, in this part of the Greenland coast all the land now visible has been recently glaciated, and so far as evidence here is concerned, there is no reason to place a limit to its advance. The presence of shells in a recently abandoned moraine, as well as in the moraine now being made, and in the ice itself, appears to prove a recent retreat of the glacier, for these shells are of species now living in the waters of the fjord. They are found at a distance of five miles from the sea and at an elevation of 586 feet above it, and at various levels below this. The description of records left near the margin of this glacier is given, with the idea of putting forward facts which will permit accurate measurement of the change of ice front in the future. This seems all the more desirable, since evidence is abundant that the glacier in this part of Greenland is now retreating at a notable rate, and that it has recently withdrawn from a considerable area. The evidence of this is found in the presence of moraines at a distance of 100 or 200 feet from the present margin of the glacier, and so recently abandoned that no vegetation has begun to grow upon the soil. Moreover, freshly scratched bedrock has been so recently uncovered by the glacier that lichens have not begun to grow.

Unconformities in Marthas Vineyard and Block Island. By J. B. WOODWORTH.

Beginning below, plant-bearing beds of Cretaceous age appear in both islands, without their base being exposed. On Marthas Vineyard marine Cretaceous strata overlie the non-marine beds; although the contact has not been worked out, unconformity is inferred from the occurrence of lignitic fragments in the overlying marine beds. Above the Cretaceous at Gay Head, and on an eroded surface rests the Miocene of Lyell and Dall, composed of the osseous conglomerate and the greensand. Overlying these beds is a yellowish greensand, possibly Miocene but probably Pliocene. Fragments of a Pliocene formation have been identified at Gay Head by Dall. There was erosion in the area during or just after Eocene time, again between the greensand and the osseous conglomerate, and between the time of the greensand and the latest Neocene, the yellowish greensand. A bowlder formation now appears, composed of rocks derived from the mainland on the north. It was preceded by local folding of the underlying beds and by erosion along narrow channels, the Miocene being locally swept away. On Block Island the earliest Pleistocene rests upon the Cretaceous at Clay Head, the Miocene being entirely wanting. Succeeding the bowlder deposits there are from twenty-five to thirty feet of granitic gravels and sands, the deposition of which was brought to a close by profound folding over Marthas Vineyard and Block Island. The Tisbury beds on Marthas Vineyard and the Mohegan Bluff beds on Block Island were now laid down upon the eroded surface of the upturned beds of older strata. These horizontal beds are evidently of glacial origin. After their deposition there came a long period of fluvial erosion, the Vineyard subepoch, in which the islands were deeply denuded, as pointed out by Shaler in 1888. On Marthas Vineyard the capture and beheadal of streams is shown in the existing topography as the work of this time. Then followed the last glacial epoch with the deposition of moraines and sand-plains.

The older Pleistocene deposits denominated Weyquosque by Shaler in 1888 appear to be the equivalent of the Columbia which in the region of the New England Islands is divisible into an upper and lower horizon, separated by unconformity of dip and erosion marking the Gay Head diastrophe. The author is unable to accept the hypothesis of glacial thrust for the deformation on the islands named because in each case the fold preceded the evidence of glaciation found in overlying bowlder deposits. Those who accept the ice-thrust hypothesis, it is insisted, must consider the work to have been done by two advances of an ice-sheet long anterior to the last glacial epoch.

In the discussion Professor Wm. B. Clark called attention to the evidence of unconformity found by him in New Jersey between the non-marine or Potomac beds and the marine Cretaceous, and also to the meagerness of the horizons in this northern extension of the coast-plain as compared with more southern fields. He suggested that an examination of the foraminiferal greensand might show that, as in New Jersey, the Miocene foraminiferal casts had at least in part been derived from preëxisting Cretaceous beds. Mr. Gilbert noted that the long erosion interval on the islands, preceding the last glacial epoch, was consistent with the history made out for the rest of the United States.

Homology of Joints and Artificial Fractures. By J. B. WOODWORTH.

A synopsis of the structure of a typical joint as described in a previous paper (*Proc. Boston Soc. Nat. Hist.*, Vol. XXVII, 1896, pp. 163–183) showed a central area of fracture termed the joint-plane, which is traversed by feather-fracture. Marginal to this is a border of overlapping fractures, traversed by cross-fractures, forming the "joint-fringe." This system of fractures *en echelon* pervades the entire joint. Specimens were exhibited showing the joint structure above described, and also examples of fracture produced by blasting in a quarry, in which specimens there was a central warped surface corresponding to the joint-plane, and a system of marginal fractures comparable to the joint-fringe. The oblique imbricating plates formed by this fracture suggest a comparison with the "diagonal fissility" of Van Hise. The obliquity in the case of joints is found of value in determining the axis of breaking tension, whatever the nature of the force which produced the joint or fracture. This axis is a normal to the oblique marginal fractures. In mapping joints, a short straight line like the "strike" line crossed by short oblique lines having the obliquity of the observed marginal fractures of the fringe was proposed as a symbol. (Not to be published in the Bulletin of the Geological Society.)

Notes on Rock Weathering. By GEORGE P. MERRILL.

This paper was in direct line with those read at previous meetings of the Society, and had to do with the ultimate products of decomposition as shown in the transition of a fresh micaceous gneiss to the condition of a bright red residual soil. The results of physical and chemical analyses were presented, and on the assumption that the alumina had remained essentially constant during the decomposition, it was shown that 44.67 per cent. of original matter had been lost through the solvent and leaching action of water. The writer stated that on the basis that such results were rather under than above the actual amounts he had from a large number of analyses been led to the conclusion that an ordinary crystalline siliceous rock of a granitic or gneissoid type in passing by decay from its fresh condition to that of soil might lose about 50 per cent. of its original constituents.

The cause of the red color of the residuary material was discussed. The writer agreed with Professor Crosby in that the color was wholly superficial, but thought that such color might be due not wholly to dehydration of the ferric oxides present, but also to the presence of a large amount of coloring matter, the iron oxides having been shown to be largely insoluble, and hence accumulating in the residue along with the alumina. The subject of zeolites in soils, and their efficacy as conservators of potash was discussed, the conclusions being that not only is there no proof of the formation of zeolites, during the ordinary processes of true weathering, but also that even did zeolites exist in the soils, such could hardly be of interest for the reason stated, since potash is not, on the whole, a prominent constituent of zeolitic minerals. In this connection Mr. Merrill suggested that the term weathering as applied to rocks should be limited to those processes going on within the zone of oxidation and resulting as a rule in the destruction of the rock was as a geological body, while the more deep-seated processes which result in the production of new minerals of the nature of zeolites, chlorite, epidote, etc., and which are really of mineralogical rather than geological moment, should be looked upon as metamorphic and designated as products of hydrometamorphism. In discussing the probable condition of the soluble constituents of soil, a brief table was given showing that in rocks of as diverse types as granite, phonolite, diabase and basalt, the percentage amount of soluble constituents in both fresh and decomposed materials may be very nearly equal.

Notes on the Potsdam and Lower Magnesian Formations of Wisconsin and Minnesota. By JOSEPH F. JAMES.

The observations recorded in this paper were made on a trip through Wisconsin and Minnesota during 1889. Starting from Madison, Wis., the route was through Lodi, Devil's Lake, Baraboo, Ableman's, Ripon, Winneconne, New London, Morritan, Hudson and River Falls, Wis., to Stillwater, Winona, and Dresbach, Minn. Natural and artificial exposures, especially in quarries, were studied at all of these places and others, and nearly all of them are illustrated by sections drawn to a scale. The most extensive section is that made between Knapp and Wilson stations on the line of the Chicago, Milwaukee, St. Paul and Omaha R. R. The distance between these two places is about five miles. There is a continuous up grade with many cuts and a number of exposures. The section extends from well down in the Potsdam up to and into the Lower Magnesian, with an estimated vertical range of about 140 feet. Two slabs of worm trails from the Potsdam of Dresbach and the Lower Magnesian of Prairie du Chien are also illustrated.

Preliminary Note on the Pleistocene History of Puget Sound. By BAILEY WILLIS.

During the past season the drift deposits about the southeastern edge of Puget Sound have been studied in some detail. They are found to consist of several beds of till, separated by stratified deposits of clay, sand and coarse gravel, together with widely distributed lignite beds. The character and extent of the glaciation of the Puget Sound region are indicated in these deposits, and it is found that the principal flow of ice was rather from the north than from the mountains on the southeast. Two problems are presented by the phenomena: (1) The sequence of glacial advance and retreat and the extent and duration of climatic changes indicated by the presence of lignites; (2) the bearing of the peculiar conditions of glacial development upon the physiography of the sound. Either the deeper valleys of the sound have been eroded during a period of high level from the once more extensive sheets of drift or, as suggested by Russell, the channels represent the beds repeatedly occupied by glaciers which in their advance and retreat built up the plateau-like eminences of the region, probably upon the divides of the preëxisting topography. The past condition of Puget Sound under confluent glaciation is probably now represented by the Malaspina glacier and its attendant phenomena.

The Leucite Hills, Wyoming. By J. F. KEMP.

The paper opened with a brief statement of our earlier knowledge of the distribution of leucite, and of the special interest that attaches to it. Outside of the European mainland localities were cited on the Lipari Islands, the Cape Verde Islands in Asia Minor, Siberia, Java, New South Wales, Kilima-Njaro, Argentina, Brazil, New Jersey, Arkansas, Lower California, Yellowstone Park, Montana, and British Columbia. The presence of the rich alkaline magmas from Montana to the Mexican line, and in or near the eastern Rocky Mountains, was commented on. The previous observations of Zirkel on the rock of the Leucite Hills were briefly summarized so as to show that the only minerals observed by him in the very limited materials gathered by the geologists of the fortieth parallel were leucite in great abundance, small prisms of augite, biotite, apatite, and magnetite, and that the remarkable absence of feldspar, haüyne, and nepheline, was a cause of surprise to him. The geographical situation of the Leucite Hills and their areal distribution was then shown by lantern slides. There are three mesas or buttes in the main group, of which the southern, or Leucite Hills proper, is the largest. Orenda Butte, two or three miles north, is next, and Black Rock Butte, five miles northeast, is the smallest of all. The two former consist of several lava sheets resting on Laramie sandstones. From them arise cones 300 feet and less in height that resemble craters, but that are solid lava. Black Rock Butte has no cone. The lava sheet is more or less dissected, but the fragments are found but a very short distance from the escarpment. Specimens from all the buttes, and from various parts of the southern one, show that while the leucite is almost always present it varies greatly in amount and may be replaced almost entirely by sanidine. Haüyne was observed, and in Black Rock Butte large augites with surrounding borders of the peculiar yellow biotite. All these points of petrographical interest were illustrated by lantern slides from photo-micrographs. The two published analyses were cited, and in view of the abundant sanidine the rock was called a leucite-phonolite rather than a leucitite. The cones were explained as due to the upwelling of a viscous lava in the final phases of activity. No tuffs or dikes were met. Pilot Knob, an isolated butte lying twenty miles further west and north of Rock Springs, was also described, and the rock was shown to consist of small needles and larger crystals of augite in an isotropic groundmass that was regarded as glass. The determinations of the rock as trachyte in the Fortieth Parallel Survey must have been due to a confusion of slides.

The Pre-Cambrian Topography of the Eastern Adirondacks. By J. F. KEMP.

The paper opened with a review of the geological formations in the Lake Champlain Valley. It was shown that Palæozoic sediments formed all the eastern shore except for a small area at the south. In Vermont the Georgian strata of the Cambrian are met, but Acadian representatives are lacking. The Georgian is only seen at a distance from the crystalline nucleus of the Adirondack Archæan (Algonkian) Island, whereas the Potsdam and Ordovician lie now well up on its flanks. Prolonged search has failed to show on the west shore of Lake Champlain anything below the Potsdam. Mr. Walcott has already pointed out these relations. The writer stated that the crystallines had all been formed and greatly metamorphosed long before the Cambrian times, whose strata on their flanks lie flat and show no metamorphism whatever. He further stated that the crystallines must have been land with an encroaching shore line during the Cambrian, and that the land was deeply carved by erosion, whose results he freely admitted had been greatly modified by faulting. Then, with a series of lantern slides based on the topographic maps of the United States

Geological Survey, he traced the relations of the Palæozoic rocks to the pre-Cambrian strata, showing that they set up into embayments at Willsboro, Essex, Westport and Port Henry. The most interesting of all are, however, at Crown Point and Ticonderoga. Small outlines of Potsdam were shown in the valley of Trout Brook, west of Rogers Rock on Lake George, and over a high divide; from the lake and in the valley of Lake George itself. The old depressions up which the encroaching sea of the late Cambrian set are still discernible. Then, with a succession of adjacent maps, the speaker traced out an old depression back from Lake Champlain through Crown Point, with several scattered outliers of Potsdam, thençe southward past Penfield Pond, and up a branch in central Ticonderoga, where another Potsdam outlier is found; thence through the valley of Paragon and Paradox lakes into the Schroon Lake valley, where a few acres of Calciferous flinty limestone remain under Schroon Lake P. O. The last named exposure is nearly twenty miles from Lake Champlain, and is forty miles from the next outcrop down the Schroon and Hudson rivers. Attention was called to the little outlier containing Potsdam, Calciferous, Trenton, and Utica strata at Wells, on the Sacondaga River, as recently figured by Mr. Darton. All these outliers are quite flat, seldom reaching fifteen degrees, and as a rule dip northwest and strike northeast. The original depressions were developed especially where there is crystalline limestone.

Stratigraphy and Palæontology of the Laramie and Related Formations in Wyoming. By T. W. STANTON and F. H. KNOWLTON.

The separation, in recent years, of the Denver, Arapahoe, and similar formations in Colorado, and of the Livingston in Montana, from the coal-bearing Laramie series, has called in question the unity of the beds usually referred to the Laramie in Southern Wyoming. Several facts in the reported stratigraphy and palæontology of the region suggested the possible presence of the Denver beds. The same horizon was suggested by the vertebrate fauna of the "Ceratops beds" in Eastern Wyoming as described by Messrs. Marsh and Hatcher. In view of these facts and queries the authors undertook the examination of the Ceratops area in Converse county, and of the coal-bearing localities along the Union Pacific Railroad, giving special attention to the stratigraphy and to the branches of palæontology—invertebrates and plants—in which they are respectively interested. The areas studied in

Converse county, the Laramie Plains, and Bitter Creek valley are described somewhat in detail, and more general observations are given on other localities treated, including Evanston and Hodge's Pass, Wyoming; Coalville, Utah, and Crow Creek, Colorado. The results are negative so far as the Denver and later related formations are concerned. That is, no division of the beds between the base of the Laramie and the Fort Union was found possible, and the Laramie age of the Ceratops beds of Converse county, as well as of the Black Buttes coal horizon, was confirmed. On the Laramie Plains most of the coal-bearing localities are on a horizon lower than the Laramie, and overlain by marine Fox Hills beds. The coal-bearing series at Point of Rocks is also in a similar position, and the considerable flora it has yielded must now be referred to the Montana formation instead of to the Laramie. In this connection all the non-marine invertebrates and plants now known from the Montana formation are brought together in lists, and the more general questions of the upper and lower delimitation of the Laramie are discussed.

A Complete Oil-Well Record in the McDonald Field between the Pittsburg Coal and the Fifth Oil Sand. By I. C. WHITE.

Geologists have long desired a careful and accurate measurement of the rocks passed through by the borings for oil in southwestern Pennsylvania. Mr. Carll, during the life of the second geological survey of Pennsylvania, had several careful records kept of the borings in Clarion and adjoining counties, but as the strata dip to the southwest, and thicken somewhat, it was very desirable to have a new standard of comparison in southern Pennsylvania. The writer happily found in Mr. T. J. Vandergrift of Jamestown, N. Y., a successful oil operator of many years' experience, the right man to undertake the work purely as a labor of love in the interest of geology. The well in question was drilled by the Woodland Oil Company, of which Mr. Vandergrift is president, on the S. B. Phillips farm in the famous McDonald field, near the line between Allegheny and Washington counties, Pa., about twenty miles southwest from Pittsburg. The producing rock of this region is the lowest member of the Venango Oil Sand group, or what is known to oil operators as the Fifth Oil Sand. This rock, it will be remembered, has yielded petroleum in greater quantity than any other yet found on the American continent, since some of the wells of the McDonald region produced oil for a short time at the rate of 15,000 barrels daily. It is no slight task to keep one of these deep-well records with the necessary care, since to be reliable a sample of the drillings must be washed, dried, and properly labeled every time the tools are withdrawn from the well. Then, too, as all rope measurements are not reliable to within ten to fifteen feet, steel-line measurements must be taken frequently, all of which was done in the present instance, so that the 2342 feet of strata, penetrated from eighty-six feet above the Pittsburg coal down to seven feet under the base of the Fifth Oil Sand, is represented by 570 samples of drillings and fifty-five steel-line measurements, from which data a very complete account of the rocks from the Pittsburg coal down nearly to the top of the Chemung may be obtained, for all of which geologists are certainly under great obligations to Mr. Vandergrift. The writer will publish the log of the well, as noted by the party keeping the same, and also a condensed record in more strictly geological terms.

A Note on the "Plasticity" of Glacial Ice. By ISRAEL C. RUSSELL.

Experiments by McConnell, Kidd, and Mügge have demonstrated that a bar of ice cut from a single crystal, with the optic axis perpendicular to two of the side faces, when subjected to a bending stress, will bend freely in the plane of the optic axis, but not at all in a plane perpendicular to that axis. In the bent crystals the optic axis in any part is normal to the bent face in that part. As stated by McConnell, the crystals behave as if they were composed of an infinite number of thin sheets of paper, normal to their optic axis, and attached to each other by some viscous substance which allowed one to slide over the next with great difficulty. The greatest freedom of movement was found to occur when the ice experimented on was near the melting point, and became less and less with a decrease of temperature. In certain of the experiments referred to the freedom of movement at —2° C. was twice as great as at —10° C. When thin sections of glacial ice are examined by means of polarized light, as shown by Deeley, Fletcher, and others, it is seen that the granules of which it is composed are fragments of ice crystals, or perhaps imperfectly formed crystals which interlock one with another so as to resemble the structure of coarsely crystalline dolomite.

The optic axes of the granules are without definite arrangement, but have all directions. Pressure brought to bear on such granular ice in a definite direction would cause movement in the crystal fragments or granules, whose optic axes were in the plane of pressure, but would not change the forms of the crystal fragments not thus oriented. The crystal fragments having their optic axes in the plane of pressure would be changed in shape, as in the experiments cited above, by movements along gliding planes. The stresses in glaciers are manifestly in various directions, and owing to the flow of the ice, inequalities of the rock surfaces beneath, etc., must be exceedingly complex. As the crystal fragments of which glaciers are composed are without orderly arrangement it is evident that some of them will be properly oriented to be deformed by a differential movement of their parts along gliding planes, by pressure acting in any direction. Under diverse stresses the resultant motion would be in the direction of least resistance. That is, the granular ice would behave like a plastic solid. The yielding of glacial ice to pressure, we conceive, is due to movements along gliding planes in the granules of which it is composed. If this process is continued the granules will evidently be destroyed by being divided along the planes on which movement occurs, but the resulting subdivisions, or "plates" perhaps we may term them, are reunited probably by the process of regelation. The plates, which after uniting have the same orientation, would form new granules. The longer this process is continued, or, in other words, the farther a glacier flows the greater the chances that a large number of "plates" will come together with similar orientation and the larger will be the resulting granules.

Under the hypothesis here suggested the granules of glacial ice are considered as an inheritance from the granules in the ice formed by partial melting and refreezing of névé snow. The granules at first are minute, but under the pressure of ice at higher levels they yield along gliding planes, and a resultant motion similar to that of plastic solids under like conditions is initiated. The granules are destroyed by this process, but progressive motion leads to the union of a constantly increasing number of the plates into which they are divided, and the growth of larger granules.

Work of the U. S. Geological Survey in the Sierra Nevada. By H. W. TURNER.

To the north of the Fortieth Parallel Mr. Diller has published one folio on the Lassen Peak area, and has a very extensive series of notes which are as yet unpublished. The gold deposits of the Sierra

Nevada are, with minor exceptions, pretty closely confined to the belt of Palæozoic and Juratrias slates with their associated greenstones and included granitic masses. The area covered by these rocks forms the real gold belt of the Sierra Nevada. It is gratifying to announce that the geological work covering this area is now nearly completed. The Marysville, Smartsville, Sacramento, Placerville, and Jackson folios are published, and the Bidwell Bar, Downieville, Truckee, Pyramid Peak, Big Trees, and Sonora sheets are soon to be published. Attention was called to the very extensive beds of Juratrias tuffs in the foothills, indicating enormous volcanic activity in Juratrias time. Later in the Tertiary the scene of volcanic activity was transferred to the crest of the range, and nearly the whole area of the gold belt was flooded with lavas chiefly of a rhyolitic and andesitic character.

Shore Lines of Lake Warren and of a Lower Water Level in Western-Central New York. By H. L. Fairchild.

This paper describes the eastward extension of the Warren shore line as discovered and traced by the author during the past summer. The beach, in excellent form, with the various shore-line phenomena, as cliffs, bars, spits, and hooks, has been traced from Crittenden to Lima, somewhat east of the meridian of Rochester; while sufficient evidence of static water at a corresponding level is found much further eastward. The altitude of the beach between Batavia and LeRoy is 880 feet above tide. The altitude at Lima, subject to possible correction of datum, is 877 feet. This water plane would lie just about 500 feet over the Iroquois plane and would apparently lie below the plane of Watkins Lake or of Lake Newberry, the early local glacial waters in the Seneca embayment. It therefore seems certain that the Warren waters never found outlet by the Horseheads channel. The comparison of the beach phenomena east of Indian Falls with the same phenomena at Crittenden and westward is difficult to make on account of the difference in the topography of the country. East of Indian Falls the beach is transverse to the drumloid molding of the land surface, and the beach is not of so mature a character as south of Lake Erie, but nevertheless indicates a long period of wave action. Another beach at an altitude of 700 feet has been found at Geneva, New York, and traced westward continuously nearly to the meridian of Canandaigua. Abundant evidence of the same water plane is found in terraces and cliffs nearly to the Genesee River. The phenomena of this shore line are nearly as strong as those of the Warren waters in the Genesee region. This beach is specially interesting as being entirely new and unexpected, and indicating a long pause of the waters at an altitude between the Warren and the Iroquois plane, while the correlating outlet is unknown. The body of the paper is a detailed description, for record, of the phenomena of these two beaches.

Principal Features of the Geology of Southeastern Washington. By ISRAEL C. RUSSELL.

A brief statement of the results of a six weeks' reconnoissance in the southeastern portion of the state of Washington, made for the United States Geological Survey.

Practically all of that portion of Washington which lies south of the Big Bend of the Columbia is occupied by a succession of basaltic lava flows. This is a portion of a vast lava-covered region embracing northern California, central and eastern Oregon, central and southeastern Washington, and southern Idaho. The great fissure eruptions which supplied the Columbia lava, as the basalt is termed, occurred in the Miocene. The Columbia lava in Washington to the west of the Columbia, south of the Big Bend, as ascertained during a previous reconnoissance, is broken by extensive faults and the blocks thus formed variously tilted. In the region here treated, however, the basalt is horizontal over extensive areas, and deeply dissected by Snake River and its tributaries. Many lava sheets, one resting on another, were seen. Between some of the flows there are widely extended sheets of lacustral clay, sand, gravel, volcanic dust, and lapilli. In some instances leaves, and the silicified stumps and trunks of trees occur in these layers. The Columbia lava flowed about the bases of the mountains of eastern Washington and the adjacent portion of Idaho, in a series of inundations which covered the low country to the south. The level basaltic plateau meets the mountains of metamorphic rock in much the same manner that the sea joins a rugged and deeply indented coast. The lava entered the valleys and gave them level floors of basalt; the deeply sculptured ridges between the valleys were transformed into capes and headlands; outstanding mountain peaks became islands in the sea of molten rock. After the last of the lava sheets was spread out, the rivers flowing from the mountains began the excavation of channels across the basaltic plateau and have deeply dissected it. The most important of these channels is the one excavated by Snake River. From the mouth of Snake River to Lewiston, the stream is a narrow, deep-sided canyon, about 2000 feet deep. Where Snake River forms the boundary between Washington and Idaho, its gorge is about 4000 feet deep and fifteen miles broad. Within this vast canyon there are many lateral ridges, and a great variety of topographic forms due to erosion. This portion of Snake River canyon compares favorably with even the most magnificent parts of the Grand Canyon of the Colorado, except that it lacks the gorgeous coloring to which so much of the charm of its southern rival is due. The thickness of horizontally bedded basalt exposed in the walls of Snake River canyon and in the adjacent Blue Mountains, is in the neighborhood of 5000 feet, but the maximum thickness is not exposed. In the walls of the canyon at three localities, the summits of steep, angular mountain ranges are revealed. One of these buried peaks rises about 2500 feet above the river and is covered by fully 1500 feet of horizontally bedded basalt. The sheets of clay, sand, and gravel interleaved with the basalt, especially near its junction with the bordering mountains, furnish conditions favorable for obtaining artesian water. A number of flowing wells derive their water supply from this source. The Blue Mountains, at least at their northern extremity, consist of a low, flat-topped dome of Columbia lava, which has been deeply dissected by consequent streams. The surface of the basaltic plateau is covered with residual soil which has an average depth of sixty to eighty feet over thousands of square miles. The soil is exceedingly fine, dark brown or black in color, and of wonderful fertility. This is the soil of the celebrated wheat lands. The subsoil is fine, light yellowish in color, without stratification, and in many localities traversed by minute, irregular, but, in general, vertical tubes. In many ways the subsoil closely resembles loess. Its origin from the disintegration and decay of the underlying basalt is clearly manifest.

Topographically the Columbia lava presents great diversity. In the Blue Mountains there is an intricate series of sharp-crested ridges, separated by a labyrinth of canyons, having in general a depth of about 3000 feet. Between the Blue Mountains and Snake River there are broad remnants of the nearly level plateau, separated by narrow, steep-sided canyons, in general 2000 feet deep. North of Snake River there is a vast area without deep canyons, but diversified by short hills from fifty to eighty feet high, none of which, however, rises above a certain general level. Along the eastern portion of this hilly plateau, or rolling prairie as it was before cultivation began, there are a few prominent, island-like buttes of quartzite, which rise through the basalt. Among the details noted in the Columbia lava are certain horizontal joints which cut the vertical columns of basalt and may be traced for several miles. The large vertical columns of lava when weathered sometimes show that they are composed of small horizontal columns or prisms which radiate from a confusedly jointed central core. The joints which bound the large vertical columns furnished the cooling surfaces for the rock they enclose. The bases or ends of the radiating columns are frequently revealed on the surfaces of the slightly weathered vertical columns by a network of lines resembling shrinkage cracks. A report on the observations outlined above will be published by the United States Geological Survey.

Old Tracks of Erian Drainage in Western New York. By G. K. GILBERT.

The glacial Lake Warren occupied the Erie and parts of the Huron and Ontario basins. In the next important stage Lake Erie was established as a non-glacial lake, being separated from the glacial Lake Algonquin at the west and the glacial Lake Iroquois in the Ontario basin. As Warren drained westward and all the lakes of the succeeding stages drained eastward, it was inferred as probable that the revolution was initiated by the opening of an eastward passage for Warren waters. Such eastward passage was sought and found in western New York. In fact several passages were found, which succeeded one another as the northward retreat of the ice-front exposed lower and lower cols on the north-south ridges which diversify the general northward slope of that region. Between the ridges there were lakelets, walled by ice on the north, and these lakelets received the material scoured out by the waters in crossing the ridges, so that the surviving phenomena are chiefly channels and scourways through the higher lands, with gravel deltas at their eastern ends. Most of the drainage lines descend to the Iroquois level, but some terminate at higher levels, and it is thought probable that for a short time a glacial lake occupied the middle Mohawk valley, being doubly dammed by ice lobes on the east and northwest.

The district traversed by the channels extends from Le Roy to Chittenango, and the relation of the channels to one another and to the Iroquois shore show that during the channel epoch the trend of the ice-front in that region was approximately east-west.

It was found also that when the water first fell to the level of the Niagara escarpment, so as to cascade over its edge, there were five points of discharge. Three of these were short-lived, but Lockport for a considerable period divided the water with Niagara.

The Physical Nature of the Problem of General Geological Correlation.

By Charles R. Keyes.

The main object of this communication has been to formulate briefly certain suggestions which have arisen in the course of recent attempts to parallel some of the geological formations in the Mississippi valley. They appear to have a much more than local bearing, and to affect the whole problem of general geological correlation, and perhaps also even our present system of geological classification.

Regarding as the principal function of correlation the establishment of a practical scale of geological succession to which may be referred the strata of all parts of the globe, the critical criteria adopted became essentially the real basis of geological classification or historical geology. A rational classification of geological phenomena reflects the genesis of the events recorded, and this is manifestly the ultimate aim of all methods of paralleling strata. In the correlation, or comparison of geological formations, experience has shown that the subject may be viewed from at least four very different points of vantage. The aspects presented are: local, provincial, regional, or general. With the various methods which have been followed from time to time in correlative inquiry the almost universal practice has been to attempt to base the broader generalizations upon criteria that are in reality applicable only to limited areas.

Passing by a review of the various methods of correlation which have been used, a little consideration shows that all are necessarily local in application and not general. This distinction between the two sorts of correlation which is usually entirely overlooked should be clearly borne in mind. When widely applied the almost total failure of the several methods that have been tried is only too apparent. The inherent weakness of the most common criteria — the fossils — is readily gleaned from the writings of Huxley, Irving, Van Hise, McGee, Walcott, Brooks and others. The problem is manifestly a physical and not a biological one. We must look therefore to physical criteria for its solution. The nearest approach to an absolute foundation for a system of geological synchrony is to be found in the work of Irving, in his work on the pre-Cambrian crystallines of the northwest, in which unconformities are given great prominence; by McGee in his investigations of the coastal plain deposits of the Middle Atlantic slope, in which similarity of genesis, or homogeny, is the governing factor; and by Davis and others in physiographic work, in which periods of base-leveling are made the all-important features in the cycle of land degradation, and inferentially the consequent sedimentation in adjoining seas.

Without considering all the available physical and biotic criteria of correlation in these various local and general phases it may be said that general correlation finds a fertile suggestion for a rational foundation in the factors which govern sedimentation. Its chief criterion is a function of continental growth and decline, and is dependent upon orogenic movement. This has recently be encalled correlation by mountain-building cycles, or orotaxis. The division planes cutting the geological columns into systems, series, or smaller parts, are actually, as well as theoretically, the lines of unconformities and their representatives. In the case of the more extensive ones they do, no doubt, represent base-leveled surfaces, or peneplains.

Modified Drift in St. Paul, Minnesota. By WARREN UPHAM.

Within the limits of St. Paul (fifty-five square miles) are numerous plateaus of drift gravel and sand, 225 to 240 feet above the Mississippi River, and about 100 feet above the highest plains and terraces of similar modified drift in the Mississippi valley. The courses of marginal moraines in this city and its vicinity, the glacial striæ, and diverse origin of the glacial and modified drift on the east and west, show that the slopes and currents of the ice-sheet converged to this area from the northeast and the northwest. On account of the sigmoid course of the Mississippi valley here, during the final melting and retreat of the ice-fields the tract where they had been confluent was occupied by a small glacial lake named Lake Hamline, which extended over the greater part of the western half of the area of St. Paul, having an outlet toward the southwest and south, across the present watershed between the Minnesota and Mississippi rivers, to Rich Valley and the Mississippi. In this temporary lake the modified drift plateaus were accumulated, their material being thought to be supplied from exceptionally abundant englacial drift brought to the area of glacial confluence. The surface of the glacial lake during the early part of its existence, as shown by the Hamline and Como plateaus, was about 250 feet above the present river, or 930 to 940 feet above the present sea level. A little later, when the plateau a mile east of Lake Como was formed, the lake level had fallen apparently five or ten feet. At the time of formation of the Summit Avenue plateau, it had been further lowered several feet, having then apparently an elevation of about 915 feet; and still later and smaller plateaus show that this lake finally was reduced to 875 or 870 feet above the present sea level. In one section it was observed that the till, exposed to a depth of twenty to twenty-five feet, at an elevation of about 875 to 900 feet above the sea, has throughout that thickness an imperfect stratification. The author attributes this to the action of the water of Lake Hamline, receiving the till from a previously englacial and superglacial position in and upon the melting ice-sheet. It is an observation almost exactly like that made by him a year earlier in the drift section of the Lake Erie shore in Cleveland, Ohio; and here, as there, he concludes that the volume of the englacial drift is represented by the thickness of the obscurely bedded or laminated till. In another section a sheet of till ten to twelve feet thick, resting on striated Trenton limestone, is shown, as the author thinks, to have been wholly englacial, this being indicated by deflection of the glacial striæ. Many of the striæ, intersecting the southward courses of earlier glaciation, run N. 60°–75° W., perpendicularly toward the neighboring Lake Hamline and its long plateaus of water-deposited drift.

(Abstracts to be continued.)